[RIVERTON FIRE AUGUST 2018] REPORT

Photo: Aerial view of the Riverton Solid Waste Disposal Site on 3 August 2018
(photo taken by Fayona Lewis)

ACRONYMS

JAAQS	Jamaica Ambient Air Quality Standards
NEPA	National Environment and Planning Agency
NO_2	Nitrogen dioxide
NRCA	Natural Resources Conservation Authority
PM_{10}	Particulate matter with an aerodynamic diameter of 10 micrometres or less
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of 2.5 micrometres or less
POPs	Persistent Organic Pollutants
RSWDS	Riverton Solid Waste Disposal Site
SO_2	Sulphur dioxide
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compounds
WHO	World Health Organization

Units

$\mu g/m^3$	microgram per cubic metre
m/s	metres per second
knot	1 nautical mile per hour (1.15 miles per hour)

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EXECUTIVE SUMMARY

This report presents the findings of the analysis of the ambient air quality monitoring data collected during the period of the fire at the Riverton Solid Waste Disposal Site, which started on July 29, 2018.

Data collection and analysis was extended in order to gauge and account for the lingering effects of the fire that continued to smoulder until August 12, 2018. This report assesses the extent of the impact of the fire on ambient air quality in the affected areas in Kingston and St. Andrew, and St. Catherine. Information on the location of the ambient air monitoring stations, the air pollutant parameters monitored and the analyses conducted are provided. The analytical results are intended to establish the bases for assessment of the impact of the emissions released during the fire event.

The monitoring sites included those operated by the National Environment and Planning Agency (NEPA) and regulated (industry) facilities within the Kingston Metropolitan Area (KMA). Monitoring for Volatile Organic Compounds (VOCs) was done using Passive VOC samplers. The VOCs were checked on July 31, 2018, during the fire and August 16, 2018 after firefighting activities had ceased. The VOC monitors were exposed for 24 hours, retrieved, and the badges prepared and subsequently dispatched to an accredited laboratory in Canada for analysis.

Parameters analysed include PM_{10}, $PM_{2.5}$, SO_2, NO_2 and VOCs. Comparative analyses were done primarily using the Jamaica Ambient Air Quality Standards (JAAQS). In instances where standards have not been established for Jamaica, comparisons were made with the United States Environmental Protection Agency's (USEPA) standards and the World Health Organization's (WHO) guidelines.

The findings are summarized as follows:

1. There was a negative impact on the ambient air quality in Kingston and St. Andrew, as well as parts of St. Catherine, including Portmore and Spanish Town.
2. The WHO 24-hour average guideline limit of 50µg/m^3 for PM_{10} was exceeded at the Spanish Town Road monitoring station on all days reviewed. The JAAQS for 24-hour PM_{10} was not exceeded, however the levels recorded are a major cause for concern. Spanish Town Road and its environs have been identified as being at risk, particularly as a result of its long term exposure to high particulate levels. At the Spanish Town Road station, the

highest PM_{10} concentration recorded during the active fire period was approximately144μg/m^3.

3. The WHO 24-hour limit (25μg/m^3) for $PM_{2.5}$ was exceeded. The highest average daily concentration of $PM_{2.5}$ (40.58 μg/m^3) recorded at the Spanish Town, St. Catherine monitoring station during the period under review was on day three of the fire. The WHO 24-hour guideline limit for $PM_{2.5}$ was also exceeded at the Duhaney Park monitoring location. The highest recorded concentration was 43.28μg/m^3 on August 3, 2018.
4. Marked increases in SO_2 concentrations were recorded at the Spanish Town Road monitoring location. The highest concentration recorded at that location was 93.48μg/m^3 on July 31, 2018; the JAAQS for 24-hour SO_2 (280μg/m^3) was not exceeded.
5. Seven (7) exceedances of the 1-hour NO_2 guideline limit were observed over the period on August 4 and 5, 2018. The highest recorded NO_2 concentration was 730.2μg/m^3 on August 4, 2018.
6. Forty six (46) pollutants were detected from the analyses conducted on VOC samples; thirty four (34) were detected above the lower concentration limit (0.2μg/m^3) of the method of analysis. The results of the analysis indicate higher than normal concentrations of benzene and toluene. The recorded benzene concentration was 41μg/m^3 at the Spanish Town Road location. This is approximately 2.5 times the highest benzene concentration detected during the 2015 fire at the RSWDS (15.3μg/m^3). The highest recorded concentration for toluene of 30μg/m^3 was just over 2.5 times the 11.2μg/m^3 concentration recorded during the 2015 fire at the RSWDS.
7. Results of the monitoring also indicated impact on air quality as a result of the Saharan Dust thereby increasing the recorded particulate matter concentrations.
8. Results indicate possible health impact especially to sensitive groups.
9. Post incident monitoring indicates general reduction in pollutant concentrations.

Overall, it can be concluded that the fire from the Riverton Disposal Facility resulted in deteriorated air quality that affected Southern St. Andrew and Kingston, as well as sections of South Eastern St. Catherine. The areas of greatest exposure included, the Three Miles to Six Miles Corridor, New Haven, Duhaney Park, Cooreville Gardens, Washington Gardens, Patrick City, Pembroke Hall and Olympic Gardens. Based on the findings, it is being recommended that the associated health effects be provided by the Ministry of Health.

1.0 BACKGROUND

On July 29, 2018, a report was received by the National Environment and Planning Agency of a fire at the Riverton Solid Waste Disposal Site (RSWDS). In response to the incident, the Agency commenced an emergency response monitoring exercise on July 30, 2018.

Assistance was sought from the Environmental Health Unit of the Ministry of Health for the monitoring of particulate matter during the period. Two (2) air quality monitors capable of monitoring for PM_{10} and $PM_{2.5}$ were provided. The monitors were used to monitor the air quality in addition to the existing permanent routine monitoring sites.

Based on the information received from the Jamaica Fire Brigade, the fire started on July 29, 2018 and was under control by July 31, 2018. The period August 1-12, 2018 consisted of a combination of observed pockets of fire which were extinguished and smouldering in some areas that could not be accessed. By August 12, 2018, however, the smoke emissions had been significantly reduced.

For the purposes of this report the period July 29 to August 5, 2018 are reviewed as the active fire period.

1.1 Data Sequestration

As a part of the ambient air quality monitoring exercise, the NEPA, in seeking to sequester additional data in relation to the incident, requested private (industry) facilities in the Kingston and St. Andrew region to provide data from their permanent ambient air monitoring sites. The selected facilities are the holders of current Air Pollutant Discharge Licences from the Natural Resources Conservation Authority (NRCA). A positive response was obtained from the licensees and the NEPA subsequently received ambient air monitoring data commencing July 26, 2018. Permanent monitoring sites previously erected in critical areas to facilitate routine ambient air monitoring were inspected and monitoring equipment calibrated to facilitate the increased frequency of monitoring during this incident. Monitoring for Volatile Organic Compounds (VOC) was also done using Passive VOC samplers. Passive samplers are small samplers that collect vapours and gases without the use of a pump. Individual chemicals simply diffuse from the atmosphere into the sampler at a fixed rate. The VOC samplers were exposed for 24 hours; the samples were subsequently retrieved, prepared and dispatched to a laboratory in Canada for analyses.

1.2 Monitoring Locations

Monitoring sites were selected based on the general wind direction, predicted impact zones, areas with high population density, critical analysis of public complaints and the availability of hosts for the monitoring equipment. Eight monitoring sites were included in the monitoring network for this incident.

The sites used are shown in Table 1:

Table 1 Monitoring Locations and Parameters monitored

SITE LOCATIONS	BASIS FOR SELECTION	Pollutant Monitored
1. JPS Offices, Spanish Town Road	Permanent Routine Ambient Monitoring Site	PM_{10}
2. Waterford Fire Station, Portmore, St. Catherine	Temporary Monitoring site	PM_{10}
3. Crossroads	Permanent Routine Ambient Monitoring Site	PM_{10}
4. 191 Old Hope Road, Kingston 8	Permanent Routine Ambient Monitoring Site	PM_{10}
5. Duhaney Park Police Station	Temporary Ambient Monitoring Site	$PM_{2.5}$
6. Port Henderson Road, Spanish Town	Permanent Routine Monitoring Site	$PM_{2.5}$
7. Red Stripe Brewery, Spanish Town Road.	Permanent Private Ambient Monitoring Site	SO_2
8. Garmex Freezone, Marcus Garvey Drive	Permanent Private Ambient Monitoring Site	PM_{10}

Monitoring was conducted for a range of pollutants, inclusive of particulate matter (PM_{10} and $PM_{2.5}$), VOCs and gases as presented in Table 1.

Samples were collected for the analyses of volatile organic compounds at the Spanish Town Road monitoring location on July 31, 2018, day 3 of the fire.

3.0 PRESENTATION OF RESULTS

3.1 Meteorological Data

Meteorological data was obtained from the Meteorological Service, Jamaica for July 31, 2018, to August 9, 2018. Based on the data received, winds speeds ranged from 1.03 – 12.35 m/s during the active period. Strong winds ranging from 10.8-13.8m/s (based on the Beaufort Wind Scale – Appendix 1) were experienced from August 2 to 4, 2018. The strong winds occurred mainly between the hours of 12:00 pm and 5:00 pm and were predominantly from a south-easterly direction (See Figure 1).

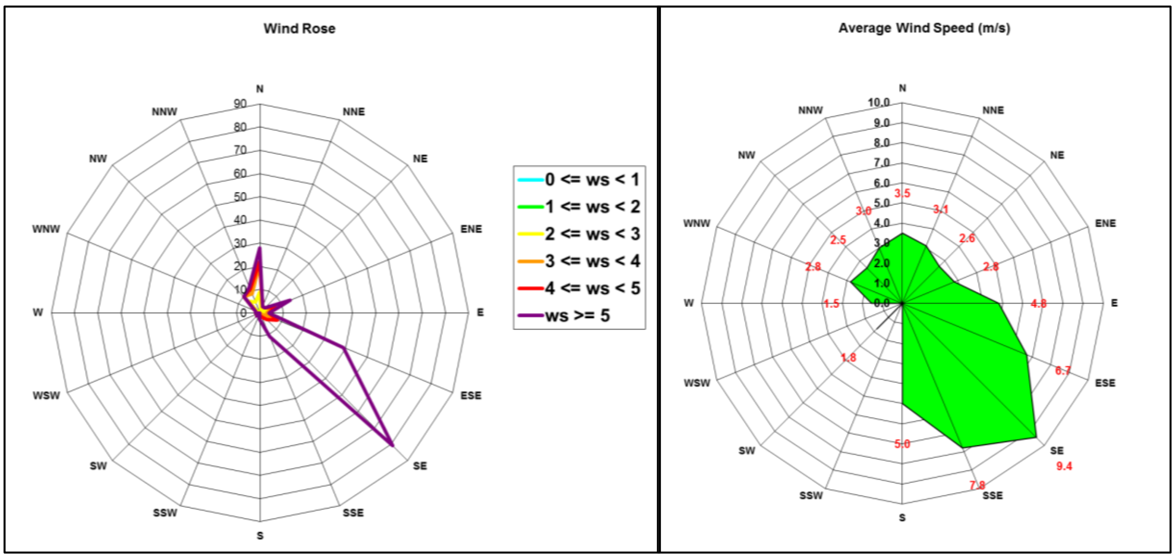


Figure 1: Wind rose plots using data from the Marcus Garvey Meteorological Station

Based on the predominant wind direction, modelled air quality data and the area represented by each monitoring location, an estimate of the areas expected to be impacted by smoke from the RSWDS was created (See Figure 2).

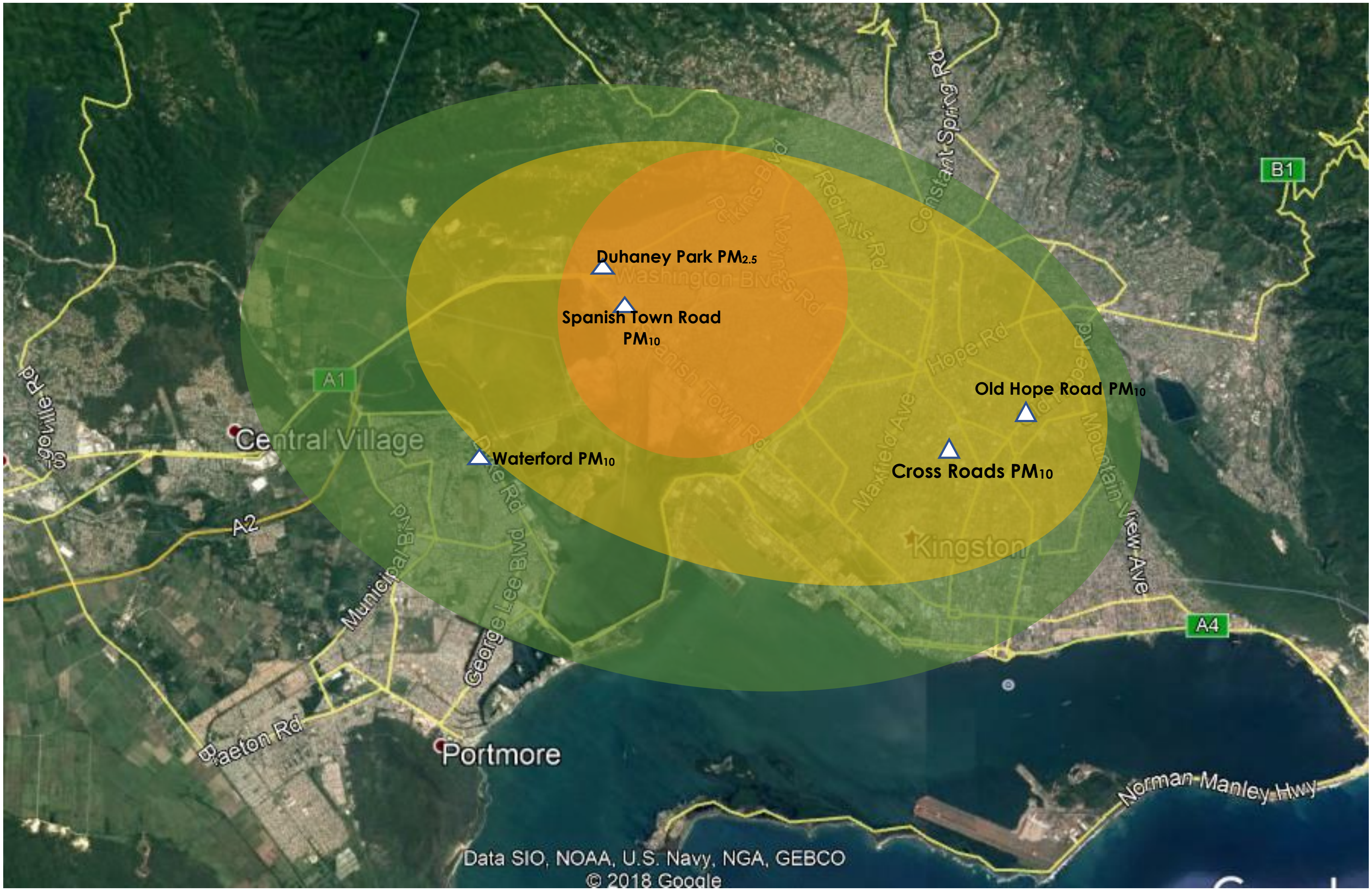


Figure 2 Satellite image of air quality monitoring points and expected impact areas

High impact | Moderate impact | Low impact

3.2 Air Quality Data

The data was collated from the various monitoring sites and is presented graphically and in tabular formats. A comparison of the data was made primarily using the Jamaica Ambient Air Quality Standards (Table 2). Where no standards have been established for Jamaica, comparisons were made with applicable WHO and USEPA limits and/or standards.

Table 2: Ambient Air Quality Standards for Jamaica

Pollutant	Averaging Time	Standard (maximum concentration in µg/m³)
TSP	Annual 24h	60 150
PM_{10}	Annual 24h	50 150
$PM_{2.5}$	Annual	12 (Primary)
	Annual	15 (Secondary)
	24 hours	35
Lead	Calendar Quarter	2
Sulphur Dioxide	Annual 24h 1h	80 (Primary), 60 (Secondary) 365 (Primary), 280 (Secondary) 700
Photochemical Oxidants (Ozone)	1h	235
Carbon Monoxide	8h 1h	10,000 40,000
Nitrogen Dioxide	Annual 1h	100 400

3.2.1 Particulate Matter – $PM_{2.5}$

The results of monitoring for $PM_{2.5}$ are presented in Table 3 and graphically in Figures 3 and 4.

Spanish Town, St. Catherine

Table 3. $PM_{2.5}$ Monitoring Results for Spanish Town, St. Catherine

Date	$PM_{2.5}$ (μg/m³)	Date	$PM_{2.5}$ (μg/m³)
30-Jul-18	38.67	8-Aug-18	¥63.50
31-Jul-18	40.58	9-Aug-18	¥56.50
1-Aug-18	32.13	10-Aug-18	39.83
2-Aug-18	27.17	11-Aug-18	33.17
3-Aug-18	37.52	12-Aug-18	30.57
4-Aug-18	28.33	13-Aug-18	32.04
5-Aug-18	29.25	14-Aug-18	31.92
6-Aug-18	38.38	15-Aug-18	33.96
7-Aug-18	40.58	16-Aug-18	26.86

Active fire period ¥ Results impacted by Saharan dust

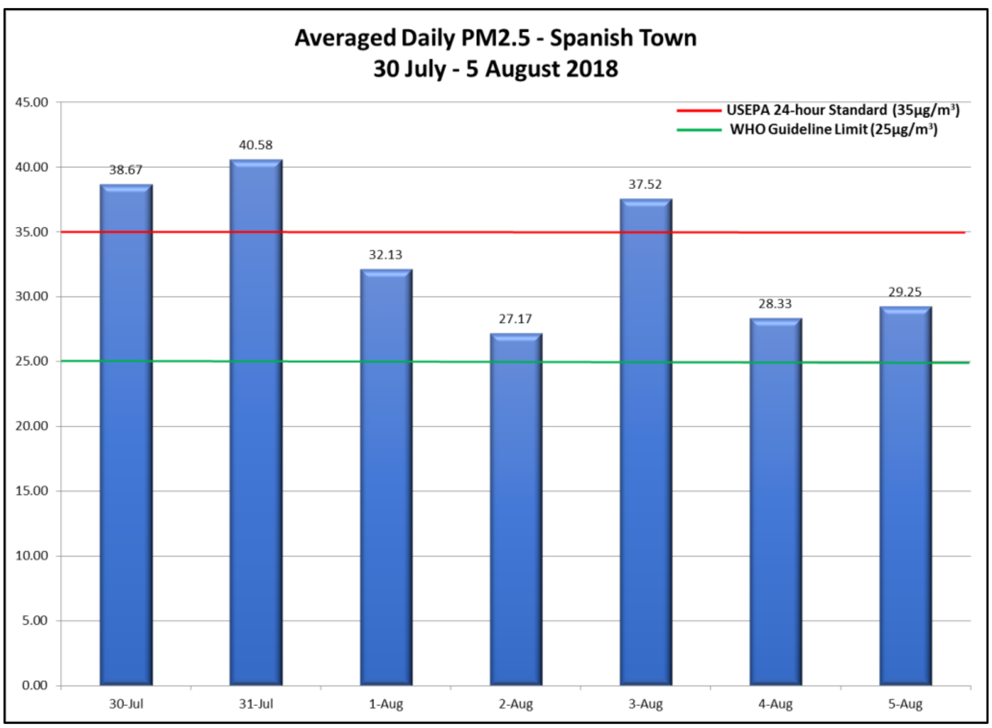


Figure 3 Averaged Daily $PM_{2.5}$ Concentrations 30 July to 5 August 2018 - Spanish Town

Daily concentrations for $PM_{2.5}$ recorded at the Spanish Town monitoring site were above both the USEPA and the WHO Guideline limits of 35µg/m³ and 25µg/m³ respectively. The highest average concentration (40.58µg/m³) recorded over 24 hours during the major fire activity period occurred on Tuesday, July 31, 2018. This is 62% higher than the WHO's guideline concentration for 24-hour exposure of 25 µg/m³. The average daily concentration of $PM_{2.5}$ recorded at this site for 2017 was 21µg/m³. A comparison of the hourly variations in $PM_{2.5}$ concentrations during the fire was made with that of 2017 (see Figure 4).

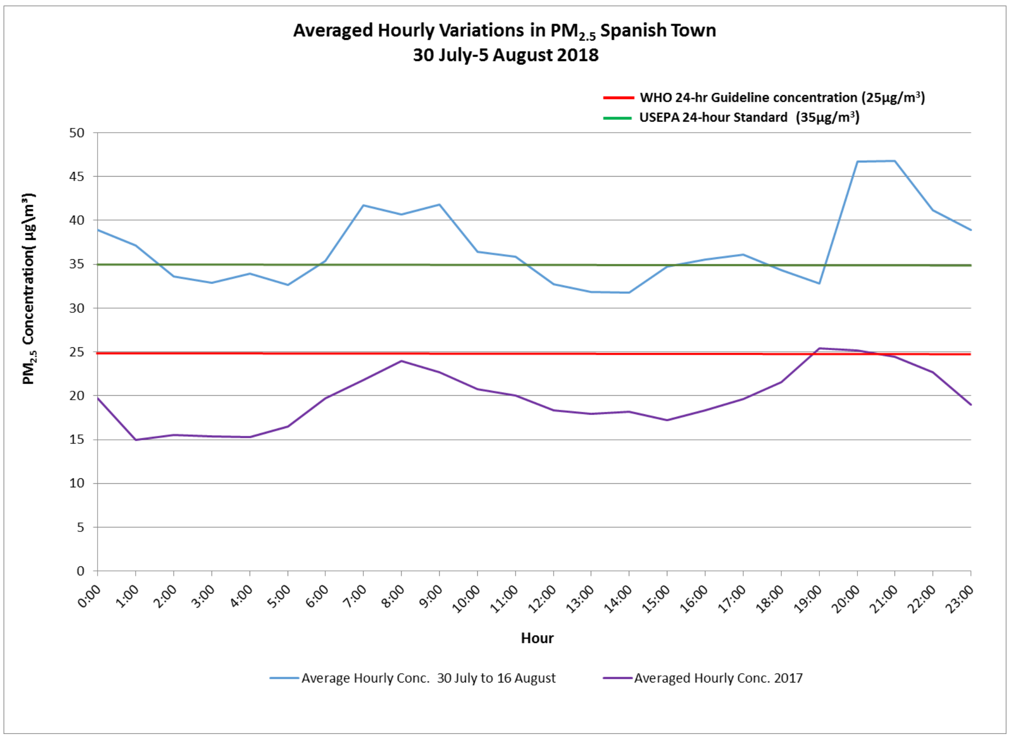


Figure 4: Averaged hourly variations in $PM_{2.5}$ concentrations for Spanish Town, 30 July - 5 August 2018

Based on the data, the hourly $PM_{2.5}$ concentrations were elevated, and in some instances this had doubled, when compared to the levels in 2017.

Duhaney Park

The $PM_{2.5}$ concentration of 22.67µg/m³ recorded at the Duhaney Park monitoring site was below the WHO Guideline Limit on July 31, 2018; however an increase in the concentrations was detected in the following days. The highest concentration (43.28µg/m³) recorded at this location during the active period of the fire was on August 3, 2018.

3.2.2 Particulate Matter – PM_{10}

The results of monitoring conducted for PM_{10} are presented in Table 4 and Figure 5.

Table 4 Results of monitoring conducted for PM_{10}

Date	PM_{10} Concentrations (µg/m³)			
	Spanish Town Road	Portmore	Crossroads	Old Hope Road
31-Jul-18	143.96	-	67.75	
03-Aug-18	79.47	19.73	45.49	33.86
Ж 08-Aug-18	159.48 ¥	-	157.92 ¥	134.43
12-Aug-18	54.91	53.33	43.75	36.25

¥ - *indicates concentration was above Jamaica's Ambient air Quality Standard for PM_{10} – 150µg/m³*

Ж *indicates impact of Saharan dust on PM_{10} concentrations*

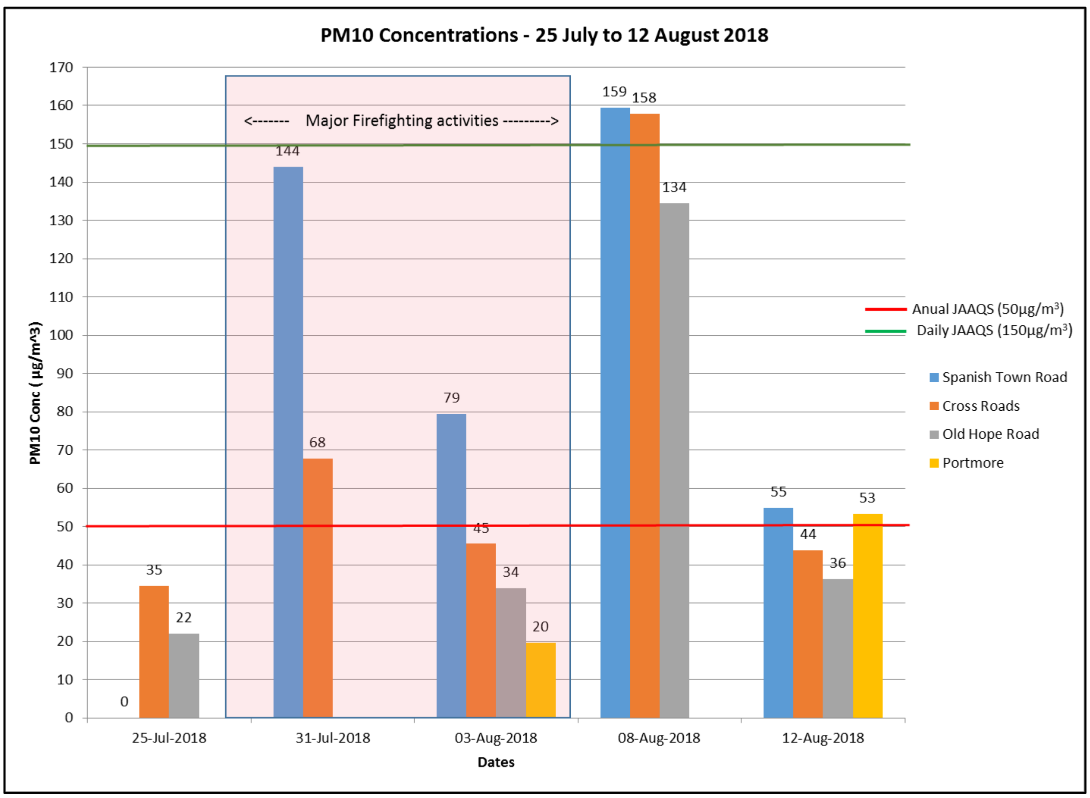


Figure 5: PM_{10} Concentrations 25 July - 12 August 2018

Figure 6 provides details of the outcome of monitoring along Spanish Town Road

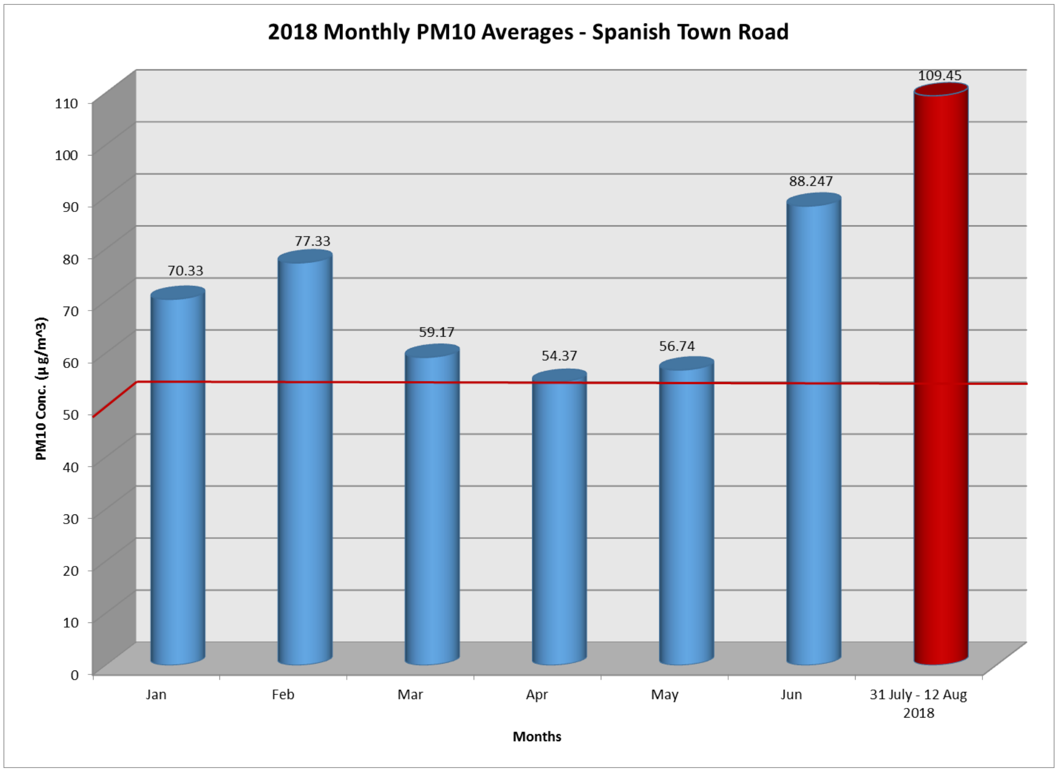


Figure 6: PM_{10} Monthly Averages - Spanish Town Road

3.2.2 Gases

Sulphur Dioxide, SO_2

The results of monitoring of SO_2 are presented in Table 5 and graphically in Figure 7.

Table 5: SO_2 Concentrations recorded at Spanish Town Road (*Source of data: Red Stripe Monitoring Station*)

Date	Spanish Town Road SO_2 Concentration (µg/m³)	Date	Spanish Town Road SO_2 Concentration (µg/m³)
26-Jul-18	-	2-Aug-18	92.35
27-Jul-18	-	3-Aug-18	60.78
28-Jul-18	23.35	4-Aug-18	31.87
29-Jul-18	34.68	5-Aug-18	25.35
30-Jul-18	53.74	6-Aug-18	6.74
31-Jul-18	93.48	7-Aug-18	58.26
1-Aug-18	76.48	8-Aug-18	42.09

Active fire period

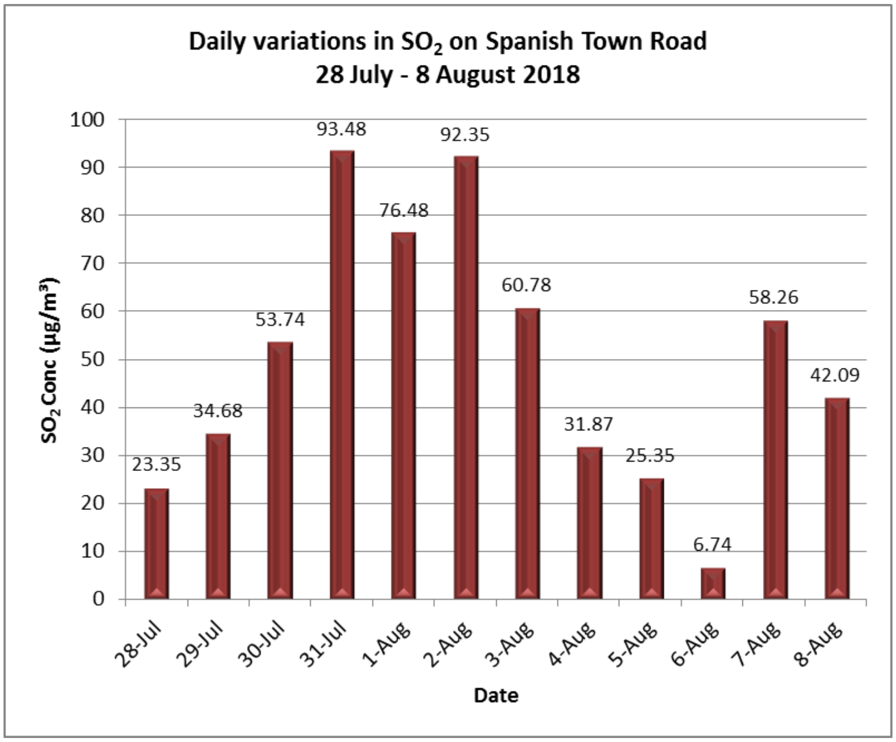


Figure 7 Daily variations in SO_2 28 July - 8 August, 2018, Spanish Town Road

Marked increases in SO_2 concentrations were recorded at the Spanish Town Road monitoring station during the period of the fire. The highest concentration recorded at that location was 93.48µg/m^3 on July 31, 2018. Based on the results, prior to the start of the fire (July 28, 2018) the SO_2 concentration was 23.35µg/m^3. The concentration recorded on the first day of the fire was 34.68µg/m^3. Notwithstanding the increases in SO_2 concentrations the JAAQS for 24-hour SO_2 (280µg/m^3) was not exceeded.

Nitrogen Dioxide, NO_2

The Nitrogen Oxides data (measured as NO_2) was analysed from the ambient air quality monitors located at Garmex, Marcus Garvey Drive. The data generated for NO_2 indicates that the maximum values for the 1-Hour standard was recorded during the period August 4–5, 2018. The hourly variations for July 28-August 5, 2018 are presented in Figure 8.

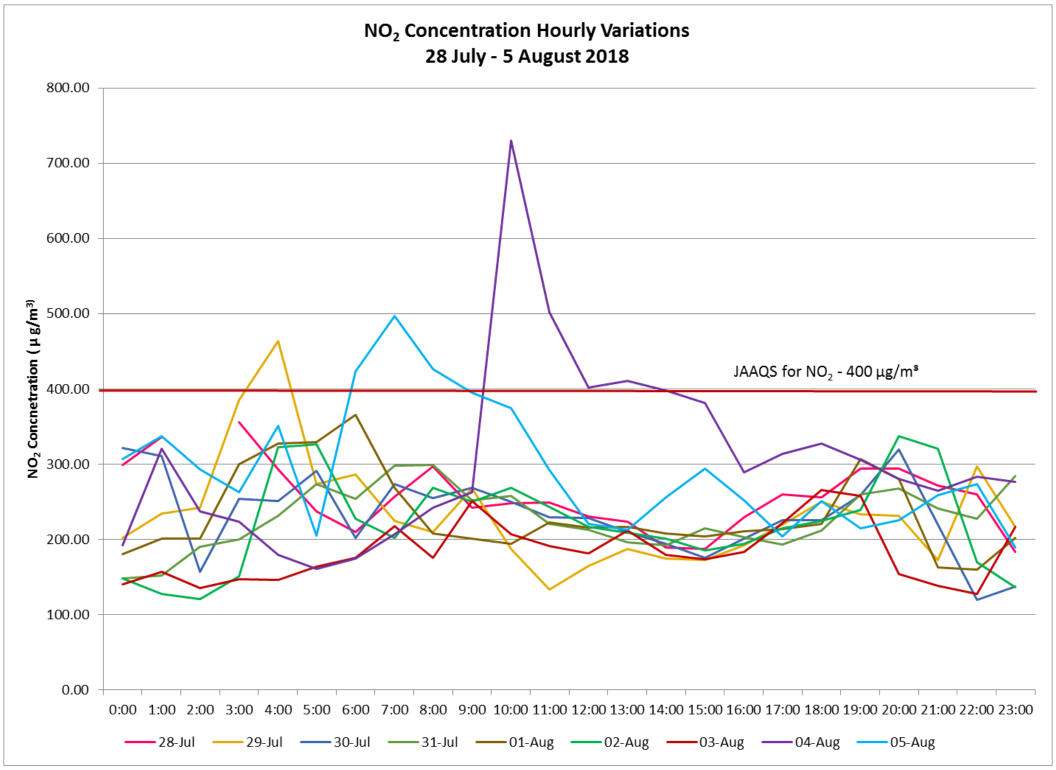


Figure 8: Hourly Variations in NO_2 26 July - 7 August 2018, Marcus Garvey Drive

3.2.3 Volatile Organic Compounds

Forty six (46) pollutants were detected from the analyses conducted on VOC samples on July 31, 2018. The results of are presented in Table 6.

Table 6 Analytical Results for Volatile Organic Compounds

	Sample I.D.	Concentrations ($\mu g/m^3$) 31 July 2018
1	Pentane (nC5)	5.70
2	Ethanol	10.5
3	2,2-Dimethylbutane	1.94
4	iso-Propyl alcohol (IPA)	19.5
5	Dichloromethane	< 0.2
6	Methyl t-butyl ether (MTBE)	0.25
7	Hexane (nC6)	0.56
8	Methyl ethyl ketone (2-Butanone)	3.44
9	Ethyl acetate	< 0.2
10	Chloroform	0.24
11	2-Methylhexane	1.12
12	Carbon tetrachloride	0.91
13	1,2-Dichloroethane	1.32
14	Benzene	41.9
15	2,2,4-Trimethylpentane	2.12
16	Heptane	3.07
17	Trichloroethylene	< 0.2
18	2-Methylheptane	1.16
19	Methyl isobutyl ketone (MIBK)	2.30
20	Toluene	30.0
21	Octane (nC8)	2.85
22	Tetrachloroethylene	< 0.2
23	n-Butyl acetate	1.30
24	Ethylbenzene	13.8
25	(m+p)-Xylene	17.7
26	o-Xylene	5.84
27	Styrene	1.94
28	Cumene	1.75
29	a-Pinene	4.75
30	1,1,2,2-Tetrachloroethane	< 0.2
31	Decane (nC10)	3.18
32	1,3,5-Trimethylbenzene	0.92
33	1,2,4-Trimethylbenzene	2.69
34	Pentachloroethane	< 0.2
35	d-Limonene	< 0.2
36	p-Cymene	0.38
37	1,3-Dichlorobenzene	< 0.2
38	1,4-Dichlorobenzene	< 0.2
39	1,3-Diethylbenzene	0.83
40	Hexachloroethane	< 0.2
41	Dodecane (nC12)	4.17
42	1,2,4-Trichlorobenzene	< 0.2
43	Naphthalene	1.18
44	1,2,3-Trichlorobenzene	< 0.2
45	Tetradecane (nC14)	8.35
46	Hexadecane (nC16)	9.39
	Total selected VOC concentration	**207**
	Number of VOCs detected	**46**
	VOC's detected above lower concentration limit	**34**

Based on the analysis 34 of the 46 VOC pollutants detected in samples collected during the fire, were detected above the lower concentration limit (0.2µg/m^3) of the method of analysis. The total concentration of VOCs was 207µg/m^3.

4.0 ANALYSIS OF FINDINGS

There was a general increase in the concentrations of the air pollutants monitored during the period of the fire. The 'fall-out' of pollutants was highly influenced by the predominant wind direction and wind speed during the period.

4.1 Meteorological Data

Based on the predominant wind speed and direction, areas to the northwest of the RSWDS were likely to experience the highest impact of the fire. Notwithstanding this, areas outside the predominant wind direction were expected to experience impacts of the fire as the wind direction changed throughout the day. Additionally, during periods of low or no wind it was expected that the smoke would remain in areas for longer periods thereby having greater impacts.

4.2 PM Data Analysis

- **PM_{10}:** While there were no recorded exceedances of the 24hr JAAQS for PM_{10}, the levels recorded were above the WHO 24-hour limit guideline of 50µg/m^3. Additionally there was a visible increase in the PM_{10} concentrations during the period of the fire. At the Spanish Town Road station, the highest PM_{10} concentration recorded during the major firefighting activities was approximately 144µg/m^3. While a higher concentration (159.48µg/$m^{3)}$ was recorded on August 8, 2018, there was visible impact of the Saharan Dust which resulted in elevated levels of PM_{10} at all the monitoring stations. This was supported by satellite images which showed a marked increase in the aerosol optical depth (AOD) across the Caribbean during the period August 6-8, 2018 (See Appendix 2).

  Aerosol Optical Depth is the degree to which aerosols prevent the transmission of light "in the atmosphere". An aerosol optical thickness of less than 0.1 indicates a crystal clear sky with maximum visibility; a value of 4 indicates the presence of aerosols so dense that it's difficult to see the sun, even at mid-day. Typical atmospheric values are between 0.1 and 0.15. AOD values greater than 0.5 constitute high aerosol loading; the AOD across the Jamaica during the period ranged from 0.4-0.6.

- **$PM_{2.5}$:** The levels of $PM_{2.5}$ recorded were above the WHO 24-hour guideline limit (25µg/m^3) for $PM_{2.5}$. The highest average daily concentration of $PM_{2.5}$ (40.58 µg/m^3) recorded at the Spanish Town monitoring station was on day 3 of the fire, Tuesday, August 31 2018.

This was 62% higher than the WHO guideline limit and is expected to have a negative impact on the population.

At the Duhaney Park monitoring location, $PM_{2.5}$ concentrations above the WHO 24-hour guideline limit was also recorded. The highest recorded concentration (43.28 μg/m^3) was 73% above the WHO Guideline Limit for $PM_{2.5}$.

4.3 SO_2 Data Analysis

The maximum hourly average concentration of SO_2 of 251μg/m^3 was recorded on 31 July 2018; the highest 24-hour average of 93.48μg/m^3 was recorded on the same day. While there were no recorded exceedances of the hourly and/or 24-hour JAAQS for SO_2 there was an increase in the concentrations recorded over the period under review. The results indicate that the fire at the RSWDS was a significant source of emission of additional SO_2.

4.4 NO_2 Data Analysis

Seven exceedances of the 1-hour NO_2 guideline limit were observed over the period August 4-5, 2018. The highest recorded NO_2 concentration was 730.2μg/m^3; this was recorded on the August 4, 2018. This value was in excess of the 1hr NRCA guideline limit of 400μg/m^3 by 82%.

4.5 VOC Data Analysis

Benzene, compounds of benzene, as well as toluene, showed the highest concentrations when compared to all the VOCs detected. The concentrations of benzene, compounds of benzene and toluene combined, accounted for 44% of the total VOC concentrations.

Benzene

Benzene and benzene compounds detected during the fire accounted for 29% (60.14μg/m^3) of the total VOC concentration (207μg/m^3). The recorded concentration of benzene and its compounds recorded was approximately 2.5 times that detected during the 2015 fire (21.94μg/m^3) at the RSWDS. The benzene concentrations recorded during the 2014 (5.81μg/m^3) fire was notably, approximately 2.5 times less than that recorded during 2015.

The guideline concentration for benzene in ambient air as stated in the NRCA (Air Quality) Regulations 2006 is 1μg/m^3 annually. This indicates that the benzene concentrations during the fire were 40 times more than the recommended annual exposure limit.

Toluene

The highest recorded concentration for toluene of 30μg/m³ was just over 2½ times the 11.2μg/m³ concentration recorded during the 2015 fire at the RSWDS. It should be noted that the 2015 fire was considerably larger (8 acres versus 60 acres), hence it is of concern that the toluene levels are considerably higher.

According to the WHO Air Quality Guideline for Europe (World Health Organization, 2000), mean ambient air concentrations of toluene in urban air are in the range 5–150 μg/m³. Concentrations may be higher close to industrial emission sources. While the concentrations of toluene are within the WHO guideline range for industrial zones, residential areas were impacted by these levels of toluene (based on the estimated areas of impact and public complaints) and would likely have negatively impacted the population.

5.0 POST INCIDENT MONITORING

The data from the monitoring sites have indicated a return to pre-existing ambient air concentrations for the pollutants monitored.

$PM_{2.5}$

Concentrations of $PM_{2.5}$ at the Spanish Town and Duhaney Park monitoring stations indicated a decline in $PM_{2.5}$ concentrations after the incident. $PM_{2.5}$ concentrations at Spanish Town had reduced to 26.86µg/m^3 on August 16, 2018. This was a reduction of 13.72µg/m^3 (34%). $PM_{2.5}$ concentrations at the Duhaney Park monitoring site had also shown a reduction from 43.28µg/m^3 on July 31, 2018 to 32.58µg/m^3 on the August 18, 2018; a reduction of 25%.

While there is a reduction in the $PM_{2.5}$ concentrations at both locations, they remain above the WHO guideline limit for daily exposure. This is an indication that there are other factors that are influencing the air quality conditions in those areas.

PM_{10}

Post incident monitoring results for PM10 are outlined in Table 7.

Table 7 Post incident monitoring results for PM_{10}

PM_{10} Monitoring Locations	Peak concentration during fire (µg/m^3)	Concentration on 18 August (µg/m^3)	Reduction	
			Concentration	%
Spanish Town Road	143.96	47.87	96.09	67%
Cross Roads	67.75	27.55	40.2	59%
Old Hope Road	33.86	23.91	9.95	29%
Waterford	19.73	67.98	-48.25	-245%

Reductions in PM_{10} concentrations have been observed at the Spanish Town Road, Cross Roads and Old Hope Road monitoring sites, however, there has been an increase in the PM_{10} recorded at the Portmore monitoring station. This indicates that there are other significant source(s) of particulate matter within that monitoring area that is/are impacting the air quality.

SO_2 and NO_2

Fluctuations in SO_2 and NO_2 concentrations were observed post incident. Reductions in SO_2 were observed starting August 3, 2018; this continued to the August 5, 2018 when the lowest concentration (6.74µg/m^3) was recorded (see Figure 7).

Reduction in NO_2 was also observed during the same period with the hourly variations for 3 August 2018 remaining below 200µg/m^3 (see Figure 8).

VOCs

Follow-up sampling for volatile organic compounds was conducted on August 16, 2018; the results are provided in Table 8.

Table 8 VOC Concentration comparison

	Sample I.D.	Concentrations (µg/m^3) 31 July 2018	Concentrations (µg/m^3) 16 August 2018
1	Pentane (nC5)	5.70	11.3
2	Ethanol	10.5	13.5
3	2,2-Dimethylbutane	1.94	< 0.2
4	iso-Propyl alcohol (IPA)	19.5	0.85
5	Dichloromethane	< 0.2	< 0.2
6	Methyl t-butyl ether (MTBE)	0.25	< 0.2
7	Hexane (nC6)	0.56	2.92
8	Methyl ethyl ketone (2-Butanone)	3.44	4.29
9	Ethyl acetate	< 0.2	< 0.2
10	Chloroform	0.24	0.24
11	2-Methylhexane	1.12	< 0.2
12	Carbon tetrachloride	0.91	0.76
13	1,2-Dichloroethane	1.32	< 0.2
14	Benzene	41.9	0.39
15	2,2,4-Trimethylpentane	2.12	2.91
16	Heptane	3.07	3.60
17	Trichloroethylene	< 0.2	< 0.2
18	2-Methylheptane	1.16	0.89
19	Methyl isobutyl ketone (MIBK)	2.30	1.67
20	Toluene	30.0	31.8
21	Octane (nC8)	2.85	0.20
22	Tetrachloroethylene	< 0.2	< 0.2
23	n-Butyl acetate	1.30	3.04
24	Ethylbenzene	13.8	4.22
25	(m+p)-Xylene	17.7	10.7
26	o-Xylene	5.84	3.38
27	Styrene	1.94	1.14
28	Cumene	1.75	0.47
29	a-Pinene	4.75	1.08
30	1,1,2,2-Tetrachloroethane	< 0.2	< 0.2
31	Decane (nC10)	3.18	3.78
32	1,3,5-Trimethylbenzene	0.92	1.74
33	1,2,4-Trimethylbenzene	2.69	1.93
34	Pentachloroethane	< 0.2	< 0.2
35	d-Limonene	< 0.2	1.06
36	p-Cymene	0.38	0.47
37	1,3-Dichlorobenzene	< 0.2	< 0.2
38	1,4-Dichlorobenzene	< 0.2	0.48
39	1,3-Diethylbenzene	0.83	0.33
40	Hexachloroethane	< 0.2	< 0.2
41	Dodecane (nC12)	4.17	4.16
42	1,2,4-Trichlorobenzene	< 0.2	< 0.2
43	Naphthalene	1.18	0.50
44	1,2,3-Trichlorobenzene	< 0.2	< 0.2
45	Tetradecane (nC14)	8.35	14.7
46	Hexadecane (nC16)	9.39	11.5
Total selected VOC concentration		**207**	**140**
Number of VOCs detected		**46**	**46**
VOC's detected above lower concentration limit		**34**	**32**
VOC's detected below lower concentration limit		**12**	**14**

The results indicate a reduction in benzene from 41μg/m³ to 0.39μg/m³. Based on the results it can be concluded that the fire at the RSWDS was a source of benzene.

The concentration of toluene increased from 30.0μg/m³ on July 31, 2018 to 31.8μg/m³ on 12 August 2018. This is an indication that the fire was not the major contributor to the toluene levels; further investigation is needed to determine the possible source(s) of toluene impacting the area. The total concentration of VOCs detected post incident was 140μg/m³; this is a reduction of 67μg/m³ (32%) when compared to that recorded during the fire. The number of VOCs (46) detected remained the same however the number detected above the 0.2μg/m³ was reduced from 34 to 32. The changes on VOC concentration during and after the incident are provided in Figure 8.

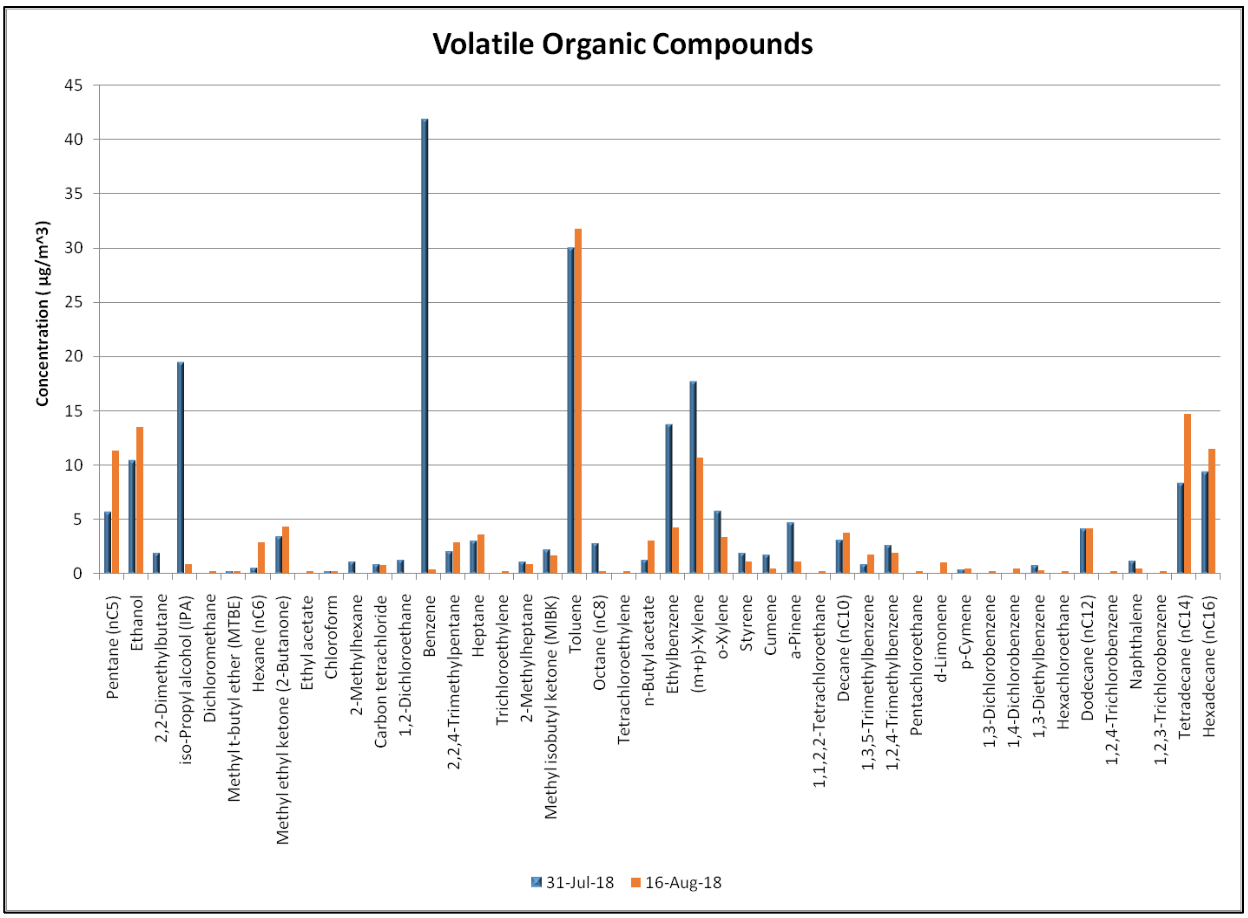


Figure 9 Volatile organic compounds comparison

6.0 RISK ASSESSMENT

The peak concentrations of PM_{10} and $PM_{2.5}$ recorded during the incident were compared with the USEPA Air Quality Index (AQI) (Appendix 3) This comparison revealed that the ambient air quality with respect to PM_{10}, was deemed unhealthy within 5 km radius of the RSWDS while at a distance greater than six (6) km it was ranked as "unhealthy for sensitive groups" (Figure 2).

The category "unhealthy" means that everyone may begin to experience health effects and members of the sensitive groups may experience more serious effects. "Unhealthy for Sensitive Groups" means that the general public is not likely to be affected at this AQI range; however, persons with heart and lung disease, older adults and children are at greater risk from the presence of particles in the air.

7.0 SUMMARY OF FINDINGS

The following represents a summary of the findings of the air quality monitoring exercise during the period under review:

1. There was a negative impact on the ambient air quality in Kingston and St. Andrew as well as parts of St. Catherine, including Portmore and Spanish Town.
2. The WHO 24-hour average guideline limit of 50µg/m^3 for PM_{10} was exceeded at the Spanish Town Road monitoring station on all days reviewed; the JAAQS for 24-hour PM_{10} was not exceeded, however the levels recorded are of major cause for concern as Spanish Town Road and its environs have been identified as being at risk, particularly as a result of its long term exposure to high particulate levels. At the Spanish Town Road station, the highest PM_{10} concentration recorded during the active fire period was approximately 144µg/m^3.
3. There were exceedances of the WHO 24-hour guideline limit (25µg/m^3) for $PM_{2.5}$. The highest average daily concentration of $PM_{2.5}$ (40.58µg/m^3) recorded at the Spanish Town monitoring station during the period under review was on Day 3 of the fire. The WHO 24-hour guideline limit for $PM_{2.5}$ was also exceeded at the Duhaney Park monitoring location. The highest recorded concentration was 43.28µg/m^3.
4. Marked increases in SO_2 concentrations were recorded at the Spanish Town Road monitoring location. The highest concentration recorded at that location was 93.48µg/m^3 on 31 July 2018; the JAAQS for 24-hour SO_2 (280µg/m^3) was not exceeded.

5. Seven exceedances of the 1 hour NO_2 guideline limit were observed over the period on August 4-5, 2018. The highest recorded NO_2 concentration was 730µg/m^3; this was August 2018.
6. Forty six (46) pollutants were detected from the analyses conducted on VOC samples; 34 were detected above the lower concentration limit (0.2µg/m^3) of the method of analysis. The results of the analysis indicate higher than normal concentrations of benzene and toluene. The recorded benzene concentration was 41µg/m^3 at the Spanish Town Road location. This is approximately 2.5 times the highest benzene concentration detected during the 2015 fire at the RSWDS (15.3µg/m^3). The highest recorded concentration for toluene of 30µg/m^3 was just over 2.5 times the 11.2µg/m^3 concentration recorded during the 2015 fire at the RSWDS.
7. Results of the monitoring also indicated impact on the air quality as a result of the Saharan Dust.
8. Results indicate possible health impact especially to sensitive groups.
9. Post incident monitoring indicates general reduction in pollutant concentrations.

8.0 LIMITATIONS OF THE RESPONSE MONITORING PROGRAMME

The Agency was unable to conduct monitoring on Dioxins, Furans and other Persistent Organic Pollutants, as it currently does not have the necessary equipment to do so.

The Agency's information is limited on the background concentrations of the priority air pollutants, which includes: VOCs, dioxins, furans and other persistent organic pollutants (POPs). Routine monitoring is required for these pollutants, which would enable the determination of background concentrations to allow conclusive statements of environmental impacts during response monitoring exercises.

The monitoring of the impacts of SO_2 and NO_2 were limited, as the present locations of the SO_2 and NO_2 ambient monitoring sites are all located upwind of the site based on the predominant wind direction.

Continuous monitoring of pollutants could not be conducted at all monitoring locations.

The associated health and socio-economic impacts of the fire are not included in this report. It is expected that the Ministry of Health will interpret the findings and predict the impact on human health.

9.0 WORKS CITED

World Health Organization. (2000). Air Quality Guidelines for Europe, Second Edition. Copenhagen: WHO Regional Publications, Europe.

10.0 APPENDICES

APPENDIX 1: Beaufort Scale

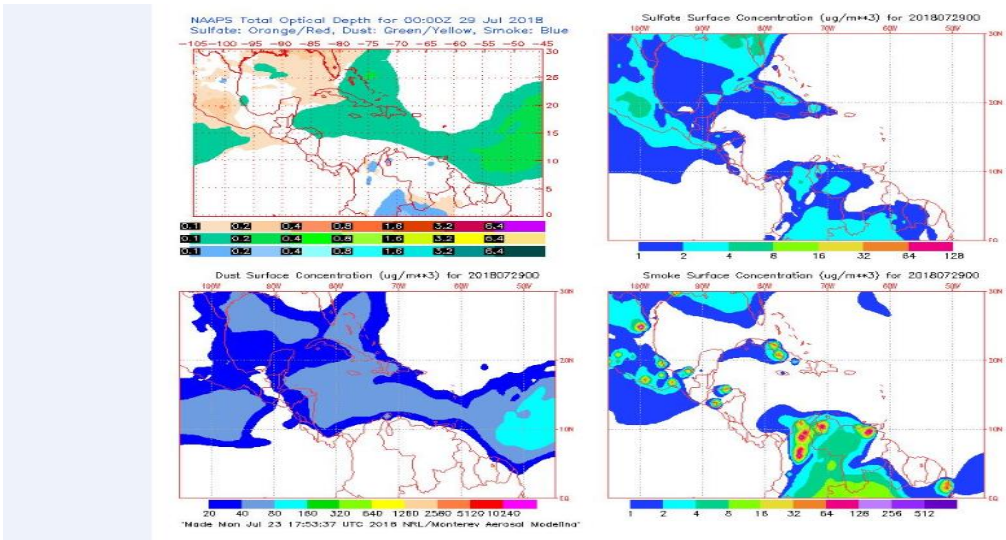
https://fishmonster.com/blogs/fishmonster-magazine-1/the-beaufort-scale retrieved 16 August 2018

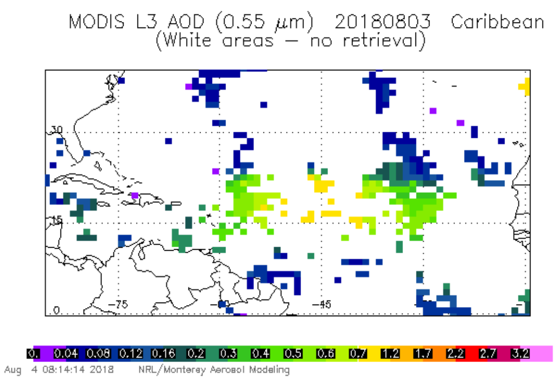
BEAUFORT SCALE

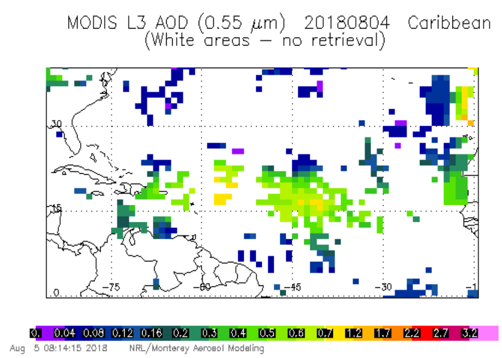
Beaufort Number	Name	Knots	MPH	Effects Observed Far From Land	Effects Observed On Land
0	Calm	Under 1	Under 1	Sea like mirror.	Calm; smoke rises vertically.
1	Light Air	1-3	1-3	Ripples with appearances of scales; no foam crests.	Direction of wind shown by smoke drift, but not by wind vanes.
2	Light Breeze	4-6	4-7	Small wavelets; crests of glassy appearance, not breaking.	Wind felt on face; leaves rustle; ordinary vane moved by wind.
3	Gentle Breeze	7-10	8-12	Large wavelets; crests begin to break; scattered whitecaps.	Leaves and small twigs in constant motion; wind extends light flag.
4	Moderate Breeze	11-16	13-18	Small waves, becoming longer; numerous whitecaps.	Raises dust and loose paper, small branches are moved.
5	Fresh Breeze	17-21	19-24	Moderate waves, taking longer form; many whitecaps; some spray.	Small trees in leaf begin to sway; crested wavelets form on inland waters.
6	Strong Breeze	22-27	25-31	Larger waves forming; whitecaps everywhere; more spray.	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.
7	Near Gale	28-33	32-38	Sea heaps up; white foam from breaking waves begins to be blown in streaks.	Whole trees in motion; inconvenience felt in walking against the wind.
8	Gale	34-40	39-46	Moderately high waves of greater length; edges of crests begin to break into spindrift; foam is blown in well-marked streaks.	Breaks twigs off trees; generally impedes progress.
9	Strong Gale	41-47	47-54	High waves; sea begins to roll; dense streaks of foam; spray may reduce visibility.	Slight structural damage occurs (chimney pots and slate removed).
10	Storm	48-55	55-63	Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks; rolling is heavy and visibility reduced.	Seldom experienced inland; trees uprooted; considerable structural damage occurs.
11	Violent Storm	56-63	64-72	Exceptionally high waves; sea covered with white foam patches; visibility still more reduced.	Very rarely experienced; accompanied by widespread damage.
12	Hurricane	64 and over	73 and over	Air filled with foam; sea completely white with driving spray; visibility reduced.	

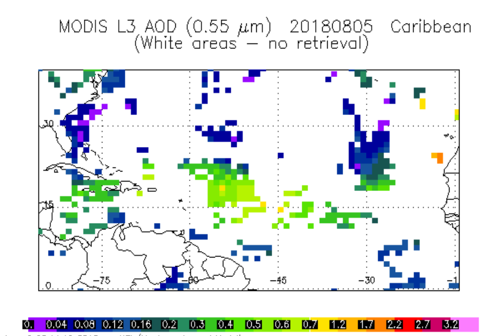
APPENDIX 2: Saharan Dust Images

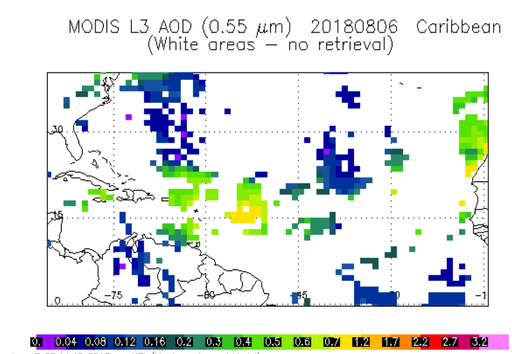
Satellite Images showing the movement of Saharan Dust across Jamaica and the Wider Caribbean

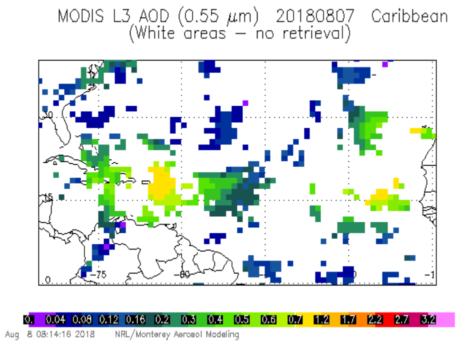


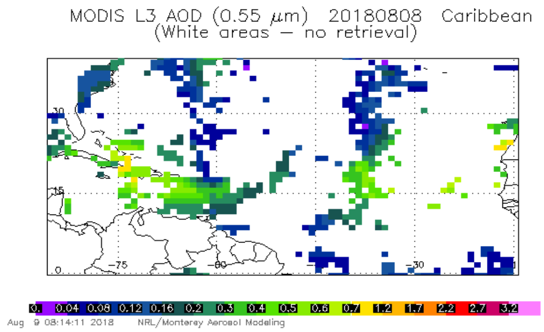












Satellite images obtained from https://www.nrlmry.navy.mil/-aerosol and

https://tropic.ssec.wisc.edu/real-time/sal 16 August 2018

Saharan Air Layer (SAL) Outbreaks: SAL outbreaks occur from the late spring through early fall and cover extensive portions of the North Atlantic between the Sahara Desert, the West Indies and the United States (e.g., Florida and Texas). These outbreaks move off the coast of Africa every 3-5 days in a layer from ~550-850 hPa (~1,500-5500 m) and can cover an area the size of the continental U.S. SAL activity (described by the size and westward reach of the outbreaks) begins to rapidly increase in early June, peaks from mid-June through late July, and begins to subside in early August. During the summer, the SAL affects ~40% of all Caribbean soundings and on average, over 20% of soundings during the peak months of the hurricane season (July-October). (*Cooperative Institute for Meteorological Satellite Studies*)

APPENDIX 3: Air Quality Index

https://ec.gc.ca/cas-aqhi/default.asp?Lang=En&n=065BE995-1#calculated)
http://airnow.gov/index.cfm?action=aqibasics.aqi retrieved 16 August 2018

What is the Air Quality Health Index (AQHI)?

The Air Quality Health Index or "AQHI" is a scale designed to help you understand what the air quality around you means to your health. It is a health protection tool that is designed to help you make decisions to protect your health by limiting short-term exposure to air pollution and adjusting your activity levels during increased levels of air pollution. It also provides advice on how you can improve the quality of the air you breathe. This index pays particular attention to people who are sensitive to air pollution and provides them with advice on how to protect their health during air quality levels associated with low, moderate, high and very high health risks. The AQHI communicates four primary things;

1. It measures the air quality in relation to your health on a scale from 0 to 500. The higher the number, the greater the health risk associated with the air quality.
2. A category that describes the level of health risk associated with the index reading (e.g. Low, Moderate, High, or Very High Health Risk).
3. Health messages customized to each category for both the general population and the ‘at risk’ population.
4. Current hourly AQHI readings and maximum forecast values for today, tonight and tomorrow.

The AQHI is designed to give you this information along with some suggestions on how you might adjust your activity levels depending on your individual health risk from air pollution.

How is the AQHI calculated?

The AQI focuses on health effects that may be experienced within a few hours or days after breathing polluted air. The Environmental Protection Agency calculates the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established national air quality standards to protect public health. Ground-level ozone and airborne particles are the two pollutants that pose the greatest threat to human health in this country.

How Does the AQI Work?

Think of the AQI as a yardstick that runs from 0 to 500. The higher the AQI value, the greater the level of air pollution and the greater the health concern. For example, an AQI value of 50 represents good air quality with little potential to affect public health, while an AQI value over 300 represents hazardous air quality.

An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level EPA has set to protect public health. AQI values below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is considered to be unhealthy-at first for certain sensitive groups of people, then for everyone as AQI values get higher.

Understanding the AQI

The purpose of the AQI is to help you understand what local air quality means to your health. To make it easier to understand, the AQI is divided into six categories:

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*..air quality conditions are:*	*...as symbolized by this color:*
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

Each category corresponds to a different level of health concern. The six levels of health concern and what they mean are:

- "Good" AQI is 0 - 50. Air quality is considered satisfactory, and air pollution poses little or no risk.
- "Moderate" AQI is 51 - 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
- "Unhealthy for Sensitive Groups" AQI is 101 - 150. Although general public is not likely to be affected at this AQI range, people with lung disease, older adults and children are at a greater risk from exposure to ozone, whereas persons with heart and lung disease, older adults and children are at greater risk from the presence of particles in the air. .
- "Unhealthy" AQI is 151 - 200. Everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects. .
- "Very Unhealthy" AQI is 201 - 300. This would trigger a health alert signifying that everyone may experience more serious health effects.
- "Hazardous" AQI greater than 300. This would trigger health warnings of emergency conditions. The entire population is more likely to be affected.

AQI colours

EPA has assigned a specific colour to each AQI category to make it easier for people to understand quickly whether air pollution is reaching unhealthy levels in their communities. For example, the colour orange means that conditions are "unhealthy for sensitive groups," while red means that conditions may be "unhealthy for everyone," and so on

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health alert: everyone may experience more serious health effects.
Hazardous	301 to 500	Health warnings of emergency conditions. The entire population is more likely to be affected.

AQI Values Assigned to PM_{10} and $PM_{2.5}$ concentrations

U.S. EPA AQI Category	PM2.5 µg/m³		PM10 µg/m³	
Good	0	12	0.0	54.9
Moderate	12.1	35.4	55.0	154.9
Unhealthy for Sensitive Groups	35.5	55.4	155.0	254.9
Unhealthy	55.5	150.4	255.0	354.9
Very Unhealthy	150.5	250.4	355.0	424.9
Hazardous	250.5	>	425.0	>

EPA's Air Quality Index (AQI) for 24-hour Fine Particle Pollution ($PM_{2.5}$)

24-hr $PM_{2.5}$ ($\mu g/m^3$)	AQI Categories	AQI Values	AQI Cautionary Statements	AQI Health Effects Statements
0 – 12.0	Good	0 - 50	None	None
12.1 – 35.4	Moderate	51 - 100	Unusually sensitive people should consider reducing prolonged or heavy exertion.	Respiratory symptoms possible in unusually sensitive individuals, possible aggravation of heart or lung disease in people with cardiopulmonary disease and older adults.
35.5 – 55.4	Unhealthy for Sensitive Groups	101 - 150	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.	Increasing likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults.
55.5 – 150.4	Unhealthy	151 - 200	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion; everyone else should reduce prolonged or heavy exertion.	Increased aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults; increased respiratory effects in general population.
150.5 – 250.4	Very Unhealthy	201 - 300	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.	Significant aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults; significant increase in respiratory effects in general population.
Greater than 250.5	Hazardous	Over 300	Everyone should avoid all physical activity outdoors; people with heart or lung disease, older adults, and children should remain indoors and keep activity levels low.	Serious aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults; serious risk of respiratory effects in general population.

Who is "SENSITIVE" to $PM_{2.5}$? "People with heart or lung disease, older adults, children, and people of lower socioeconomic status are the groups most at risk." Also at higher risk: **prenatal children** (low birth weight, pre-term birth, and IQ reduction), **diabetics**, and people with higher exposures such as **athletes** exposed during exercise.

Sources: http://cleanairfairbanks.files.wordpress.com/2013/01/aqi-chart-for-pm-2-5-pollution-2013.pdf

2013 by **Clean Air Fairbanks** cleanairfairbanks@gmail.com http://cleanairfairbanks.wordpress.com

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